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ABSTRACT

This booklet of exercises and activities to help students learn the fundamentals of the metric system is designed for elementary, junior high school and senior high school students. It is organized under four topics (Length, Weight, Volume, and Putting it All Together Activities) and comes packaged with an ungraded thermometer, metric rulers, and a 1-gram centimeter cube. The activities and exercises can be simplified or extended to meet the needs of the class or individual students. An answer key is included as the final section. (JP)

METRIC Exercises

LIVELY ACTIVITIES ON LENGTH, WEIGHT, VOLUME, AND TEMPERATURE

National Science Teachers Association
1201 Sixteenth Street N.W.
Washington, D.C. 20036

Stock Number 471-14664
Price $6

generally used equivalents in the metric system

Length

millimeter	mm	10 mm	= 1 centimeter
centimeter	cm	100 cm	= 1 meter
meter	m	1,000 m	= 1 kilometer
kilometer	km		

Mass (weight)

gram	g	1,000 g	= 1 kilogram
kilogram	kg	1,000 kg	= 1 metric ton or tonne (t)
metric ton			

Volume

milliliter	ml	1,000 ml	= 1 liter
deciliter	dl	10 dl	= 1 liter
cubic centimeter	cm^3	1,000 cm^3	= 1 cubic decimeter = 1 liter
cubic decimeter	dm^3	1,000 dm^3	= 1 cubic meter
cubic meter	m^3		

Time

second	s	60 s	= 1 minute

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Notes to the Teacher

Metric Is Coming introduces the modernized metric system, International System of Units (SI), as background for the teacher.

Metric Exercises

The exercises and activities in this collection are designed for elementary, junior high school, and senior high school students. They can be simplified or extended to meet the needs of the class or of individual students. An answer key is included as the final section of this booklet.

The overall purpose is to help students learn the fundamentals of the metric system and to provide introductory exercises and activities. Through these and similar activities, students can become familiar with the terminology and units of the metric system and see how it can be applied to their everyday needs. The exercises and activities also offer practice in mathematics skills.

Each exercise or each activity is complete in itself and will need only beakers, bunsen burners, balance, or other usual classroom equipment in addition to the equipment provided in this kit. The balance should be calibrated for at least tenths of grams. The centimeter cube weighs one gram.

For the activity Metric in a Thermometer, we have suggested distilled water since the minerals in ordinary tap water might affect the accuracy of the measurement. Altitude above sea level will also affect the measurements. We suggest that you or one of the students run through the activity once, using a calibrated thermometer as well as the uncalibrated one to verify the temperatures achieved.

This run-through is important, too, as a check for safety precautions with your equipment. The purpose of the exercise is to help the students understand the basis of the Celsius scale. Don't be too concerned if their techniques and facilities are less than perfect or if the students cannot achieve an accurate calibration.

We hope that teachers and students will adapt these exercises and devise others to associate the use of the metric system with familiar things. Classroom quantities of the exercises and activities may be duplicated from these pages.

Additional quantities of the thermometer tube, plastic ruler, and Cube-O-Grams are available from:

Thermometer—Selective Educational Equipment, Inc., 3 Bridge Street, Newton, Massachusetts 02195. Tubeoo uncalibrated thermometer tube, 20 cents each.

Ruler—Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. NBS Special Publication 376, 10 cents each.

Cube-O-Gram—Ohaus Scale Corporation, 23 Hanover Road, Florham Park, New Jersey 07932. 100 of one-color, $3.50; 100 each of ten colors, $27.50. Manual free with 1000 cubes; otherwise, $1.

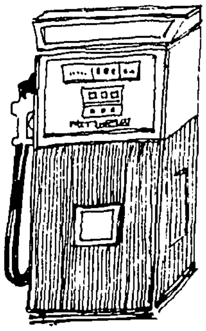
METRIC EXERCISES

Contents

Recognizing Everyday Metric

Write the metric unit that relates to the following pictures

1.



liter

2.

_____

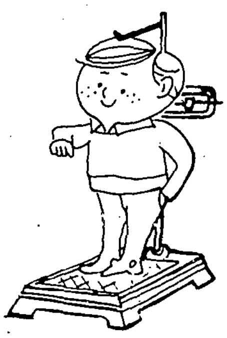
3.

_____

4.

_____

5.



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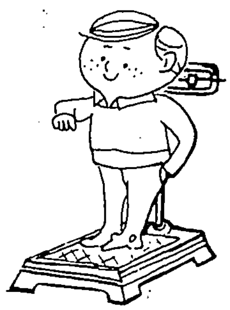

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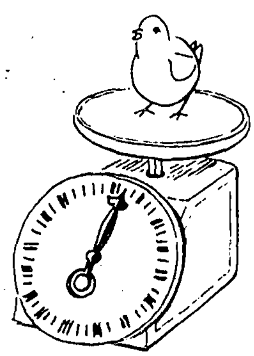

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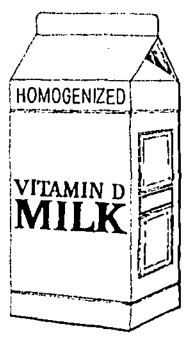


_____

Length

Measuring Length and Distance

1. How many millimeters in 1 meter? ________ in 1 centimeter? ________
   How many centimeters in 1 meter? ________
   How many decimeters in 1 meter? ________
   How many meters in 1 kilometer? ________

2. Fill in the following blanks.

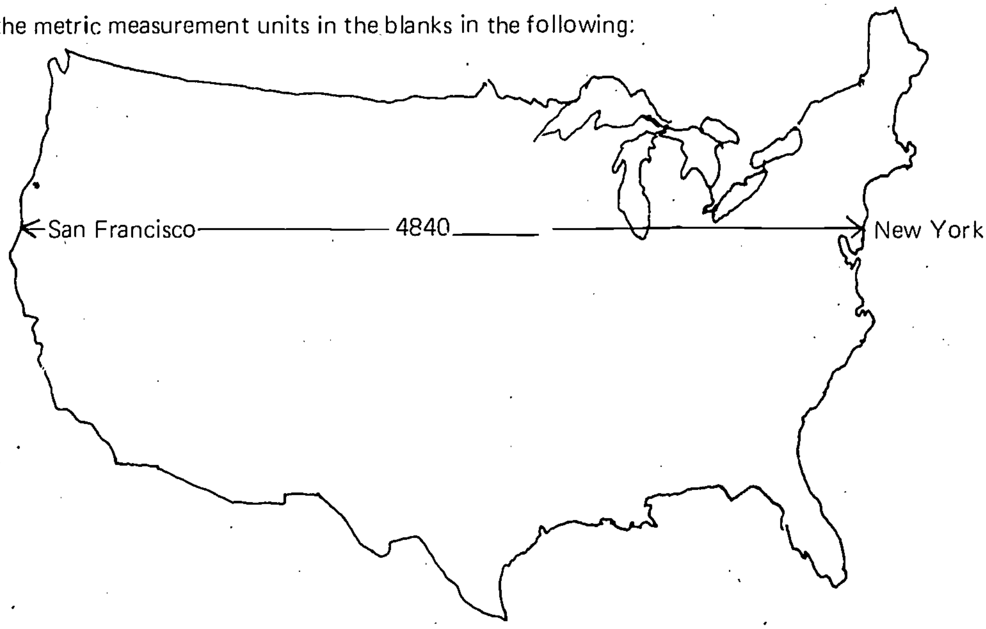
7 meters	=	________	decimeters
7 meters	=	________	centimeters
7 meters	=	________	millimeters
________ meters	=	1 kilometer	
100 centimeters	=	________	meter
50 centimeters	=	________	meter
1 meter	=	________	centimeters
5 kilometers	=	________	meters
2,000 millimeters	=	________	meters

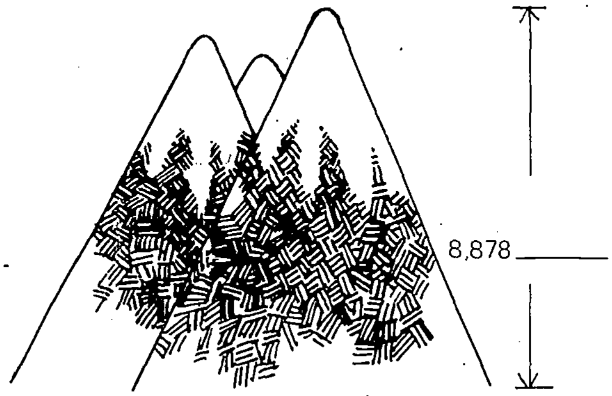
3. Measure 2.6 meters.
   Measure the same distance in decimeters.
   Measure the same distance in centimeters.
   Measure the same distance in millimeters.

4. Outdoors, measure 10 meters.
   What is this distance in centimeters? ________ in kilometers? ________

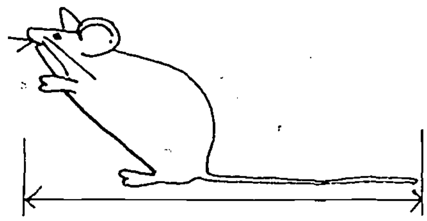
Practicing the Units of Length and Distance

Add the metric measurement units in the blanks in the following:

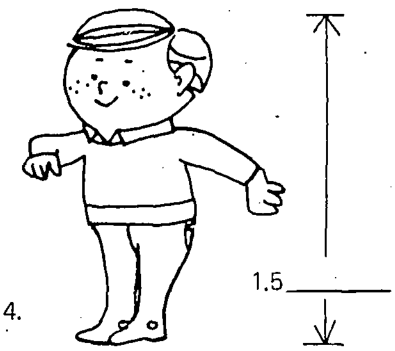




2. Mt. Everest



3. Mouse 10 ______



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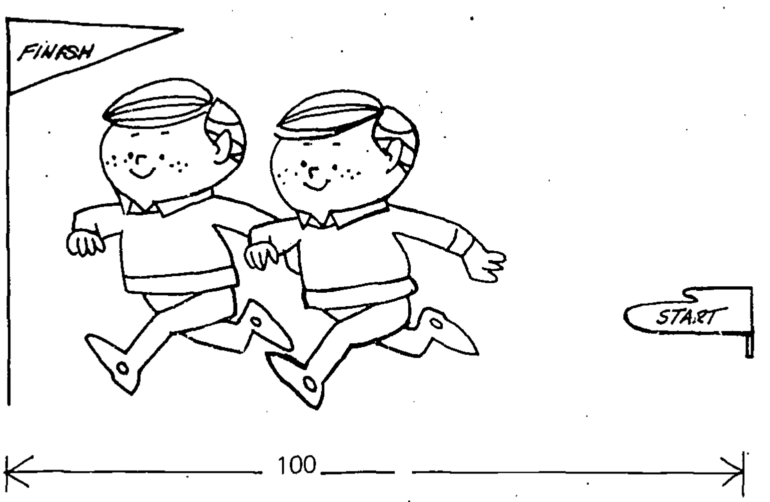


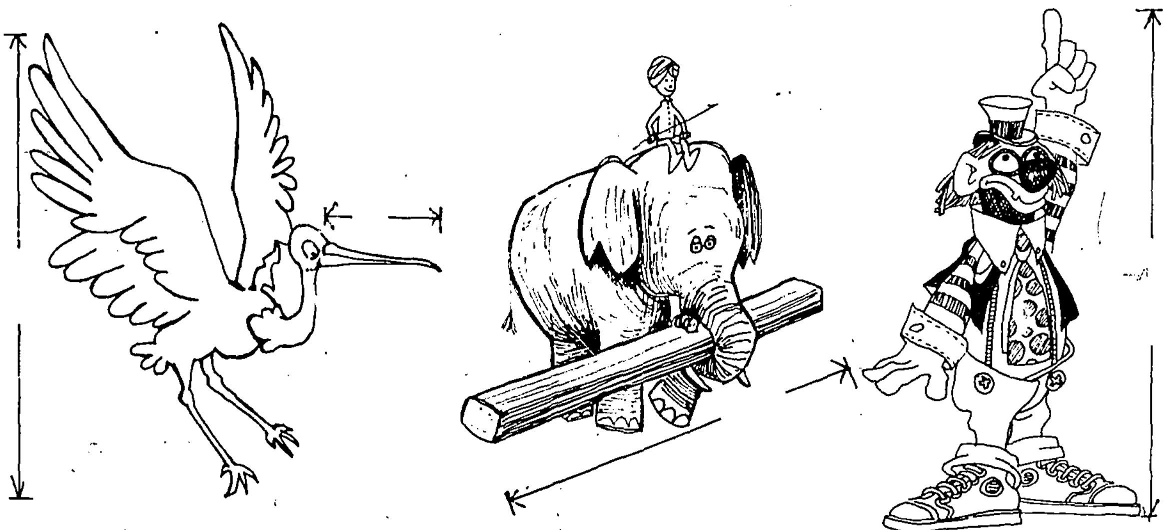
Changing from One Unit to Another

Estimating and Measuring

Convert (change) the following measurements to centimeters (cm). Then change them to millimeters (mm). Look at your metric ruler to see how large the units are.

	meters m	centimeters cm	millimeters mm
Example:	2	200	2000
	8.6	______	______
	7.5	______	______
	3.02	______	______
	.75	______	______
	.50	______	______
	.42	______	______
	.20	______	______

2. *Estimation Exercises.* Make an "educated guess" as to the indicated dimensions of the following drawings. Then measure with your ruler to see how close you came.



______cm ______cm ______cm ______cm

3. Convert the following measurements to meters and centimeters:

	meters and centimeters	meters in decimal fractions	two objects separated by about this distance
Example: 110 cm	1 m 10 cm	1.10	______
185 cm	______	______	______
376 cm	______	______	______
592 cm	______	______	______
850 cm	______	______	______
105 cm	______	______	______

4. Look around the room you are sitting in. Estimate the length and width of the room. List two objects in the room which are ***roughly*** separated by each distance mentioned above.

Traveling in Metric

1. Bill's father made three trips in his car in one day. The distances were:
   5 kilometers
   45.5 kilometers
   27 kilometers

   If the odometer on his car read 50,783 km at the beginning of the day, what would it read when he finished the third trip?

   If he used 12 liters of gasoline, how many kilometers per liter did he get on this day's driving?

2. Debbie lives 2 kilometers from her aunt and 30 kilometers from her grandmother.

   Fill in the following blanks.

   Debbie often rides her bicycle to her ______________ house. She does not ride her bicycle to visit her grandmother because ____

   ____________________. How much farther is it to her grandmother's house than to her aunt's house? ____________________________

Jumping in Metric

1. Jack is practicing long jumps. He has Bill measure 8 jumps and record the distance for each in meters. The distances were:

Jump	Distance
1	1 m 6 cm
2	99 cm
3	1 m 32 cm
4	1 m 45 cm
5	1 m 60 cm
6	2 m 8 cm
7	2 m
8	1 m 50 cm

What was Jack's average jump?
(Clue—Add all of the distances and divide by the number of jumps)

In what three ways can you do the addition?
1. Convert all the distances to centimeters
2. Express all of the distances in decimal numbers
3. Add all of the meters—then add all of the centimeters and convert to meters and add to the first total of meters

What was the difference between the shortest and the longest jump?

Which way is the simplest?

Then divide the total by 8 for the average. It is ______________________________

2. With a buddy, try to stand apart at about the distance of Jack's average jump (make a "guesstimate"): ______________ Then,

3. Take a meterstick and determine the length on the floor that is equal to Jack's average jump. (Use masking tape to mark beginning and end.)

Weight

Learning about Weight

1. How many grams (g) in 1 kilogram (kg)? ________
   How many kilograms in 1 metric ton? ________

2. Fill in the following blanks.

500 grams	=	____________	kilogram(s)
250 grams	=	____________	kilogram(s)
2 kilograms	=	____________	gram(s)
5 kilograms	=	____________	gram(s)
3,000 kilograms	=	____________	metric ton(s)
500 kilograms	=	____________	metric ton(s)
1,000g	=	____________	kg
10g	=	____________	kg
450g	=	____________	kg
2,000g	=	____________	kg

3. Go outside and collect a sample of soil (gravel, sand, wood, stones, etc.) which you would estimate to weigh about 500 grams. Weigh the sample and see how close you are. Then try again.

4. Find a single object in the classroom which you think would be closest in weight to 1 kilogram.

5. Construct your own standard kilogram weights for use in weight comparisons (jars of water, boxes or plastic bags of sand, or wooden blocks could be used.)

6. Select an object that you think will weigh the same as the centimeter cube. Then weigh it. How close did you come to estimating the correct weight?

Changing from One Unit to Another

Practicing Metric Weights

1. Convert the following measurements to kilograms and grams and decimal fractions of kilograms:

grams	kilograms and grams	kilogram: decimal fractions
Example: 2500	2 kg and 500 g	2.5 kg
5860	________	____________
8000	________	____________
3500	________	____________
7250	________	____________
1005	________	____________

2. Lunch
   Suppose that this is your lunch and weigh each item:

Solids

2 slices white bread	=	________	g
2 slices whole wheat bread	=	________	g
margarine	=	________	g
2 slices of bologna	=	________	g
peanut butter	=	________	g
apple	=	________	g
Total		________	g (or kg)

Liquids

1 glass milk	=	________	l (or dl)
soda	=	________	l (or dl)
Total		________	l (or dl)

How many grams of food did you eat? ________

How many deciliters of liquid did you drink? ________

3. Convert the following measurements:

kilograms (kg)		grams (g)
.5	=	____
.15	=	____
.6	=	____
1.3	=	____
.25	=	____

metric ton		kilograms (kg)
.75	=	____
1	=	____
.5	=	____
3	=	____

4. The class is planning a cookout with hamburgers. The students figure 100g of meat per hamburger. If there are 15 students in the class and each will eat 2 hamburgers, how much meat will the class have to buy?

5. One cubic centimeter of water weighs approximately 1 gram.
How much will 1000 cm^3 weigh? ________ 100 cm^3? ________ 3 deciliters? ________

6. Estimate the weight of a glass of water. First weigh the empty glass. ________ g.
Then weigh the glass of water ________ g. The weight of the water is ________ g.
How many cubic centimeters of water are there in the glass? ________ cm^3.

7. The class is studying nutrition and how much weight a child gains in a year.
Following are last year's and this year's weights for five children. What was the difference for each of them? What was the average change in weight during the year? What was the average gain in weight?

child	weight (kilograms) last year	this year	difference (kg)
Jim	30.4	39.2	________
Tom	35.1	40	________
Sally	31.6	35.7	________
Karen	28.2	34.8	________
Bill	39.1	38	________

________ average change

________ average gain

8. In the supermarket, one brand of canned fruit comes in three sizes:

200g 20 cents 450g 37 cents 1,000g 65 cents Which size is the "best buy"? ____

Volume

Measuring Volume in Metric

1. How many cubic centimeters (cm^3) in 1 cubic decimeter (dm^3)? __________
   How many cubic decimeters (dm^3) in 1 cubic meter (m^3)? __________
   How many cubic decimeters in 1 liter (l)? __________
   How many deciliters (dl) in 1 liter (l)? __________

2. Fill in the following blanks:

10 deciliters	=	__________	liters
6,000 cubic centimeters	=	__________	decimeters
6,000 cubic centimeters	=	__________	liters
500 cubic decimeters	=	__________	cubic meters
800 dl	=	__________	l
1,000 cm^3	=	__________	dm^3
4,000 dm^3	=	__________	m^3
__________ l	=	1 m^3	

Practicing Volume in Metric

1. Sally and Jim are going to make soda punch for a class party.
   The punch bowl holds 8 liters. They plan to use half fruit drink and half plain soda.

   How much fruit drink will they need? __________ liters.

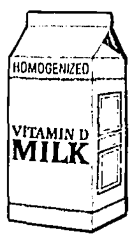
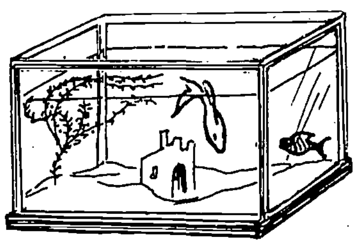
   How much soda will they need? __________ liters.

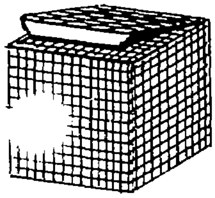
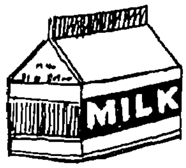
   The fruit drink cans hold 1.2 liters each. How many cans will they need? __________

   The soda cans hold .4 liter each. How many cans will they need? __________

Estimating and Measuring

Estimate the volume of the following. Then measure the volume to see how nearly accurate you were.

	Volume	
	Estimated	Measured
	______ liters ______ cm^3	______ liters ______ cm^3
	______ liters ______ cm^3	______ liters ______ cm^3

	______ cm^3	______ cm^3
	______ liters ______ cm^3	______ liters ______ cm^3
	______ liters ______ cm^3	______ liters ______ cm^3

1. Using the squared paper construct a container that has a volume of 1 cubic decimeter or 1 liter.

If this container is a cube, what are its measurements:
length__________ ; width__________ ; depth__________

The squared paper may also be used to cover a milk carton to make it a liter carton, and a half-liter container.

2. Fill the half-liter container with sand or pebbles. Estimate the quantity of water that can be added to the container of pebbles ________ cm^3. Now pour a measured amount of water into the container. How much could you add?______ cm^3.

If the container were filled with sand, could you add more or less water than for the pebbles?__________
Why? __________________ . Try it.
How much water could you add?____________________

3. Estimate the volume of your textbook and four other objects in the room and measure the volume.

Object	Volume Estimated	Measured
Textbook	__________	__________
__________	__________	__________
__________	__________	__________
__________	__________	__________
__________	__________	__________

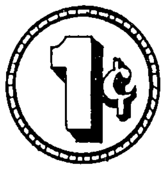
4. How can you measure the volume of an irregularly shaped small rock or piece of concrete? Estimate and measure the volume of a rock.

5. How can you measure the volume of an irregularly shaped container, a vase for example. Estimate and measure the volume of such a container.

Putting It All Together

Fill in the blanks with the best answers from the right-hand column.

1. How much do they weigh?



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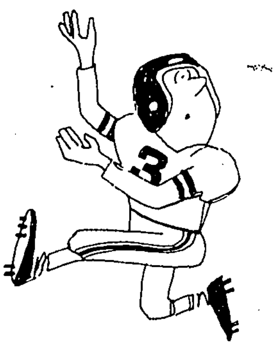

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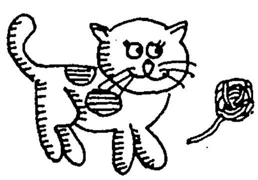


____

10 grams

70 grams

6 kilograms

40 kilograms

100 kilograms

1 kilogram

2. What's the temperature?

0° Celsius

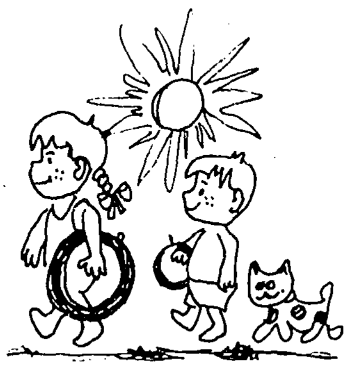
100° Celsius

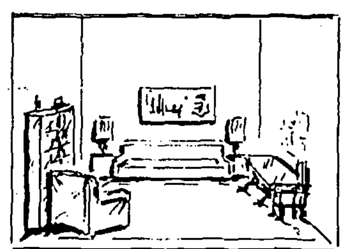
37.5° Celsius

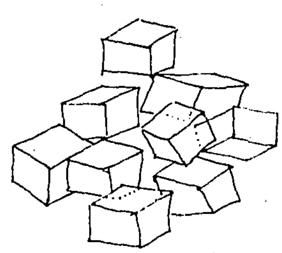
20° Celsius

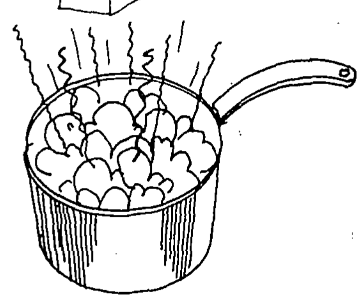
40° Celsius

−10° Celsius

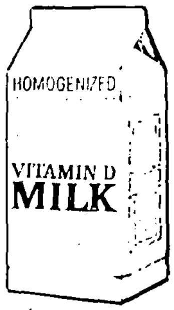








3. What is the volume?

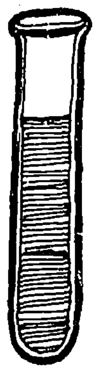


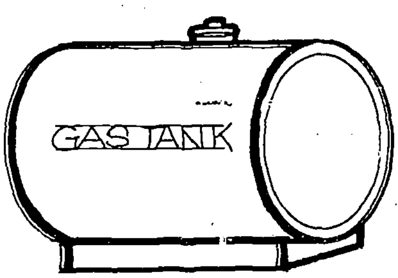
1 liter

15 milliliters

.25 liters

50 liters



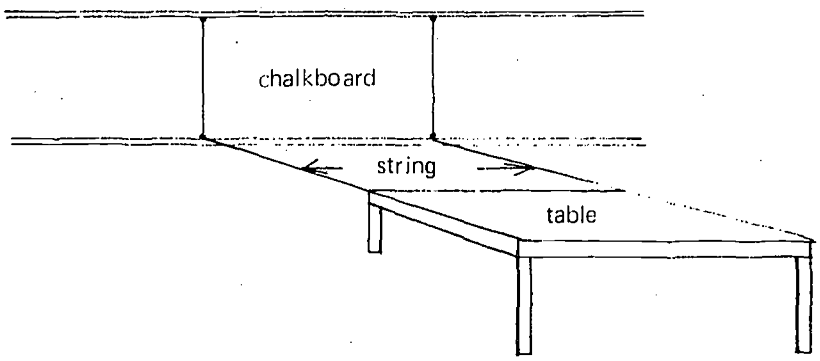


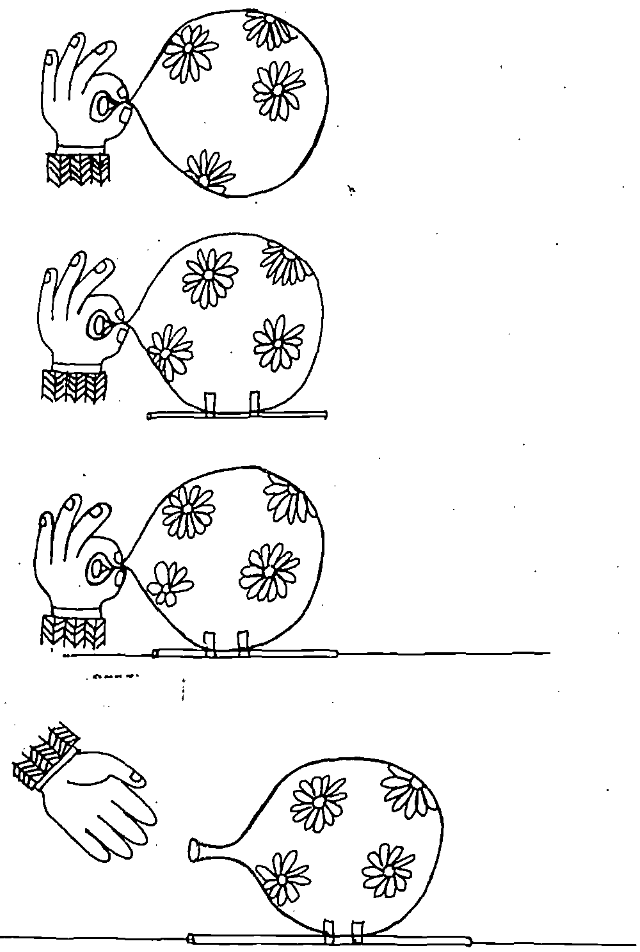
Metric in a Jet

Requirements:

For each group of 3 or 4
Long and round balloons
String
Straws
Metric ruler

1. Tie string from front of room to back of room or to a table several meters from the chalkboard





2. Blow up balloon (keep air in balloon by holding it).

3. Tape on a straw

4. Put string through straw

5. Let go of balloon so that balloon goes up the string

6. Measure the distance.
(If balloon whirls around, it slows down force and the measure won't be accurate) (Re-measure it). Try it with both long and round balloons, which goes farthest?

Metric on Wings

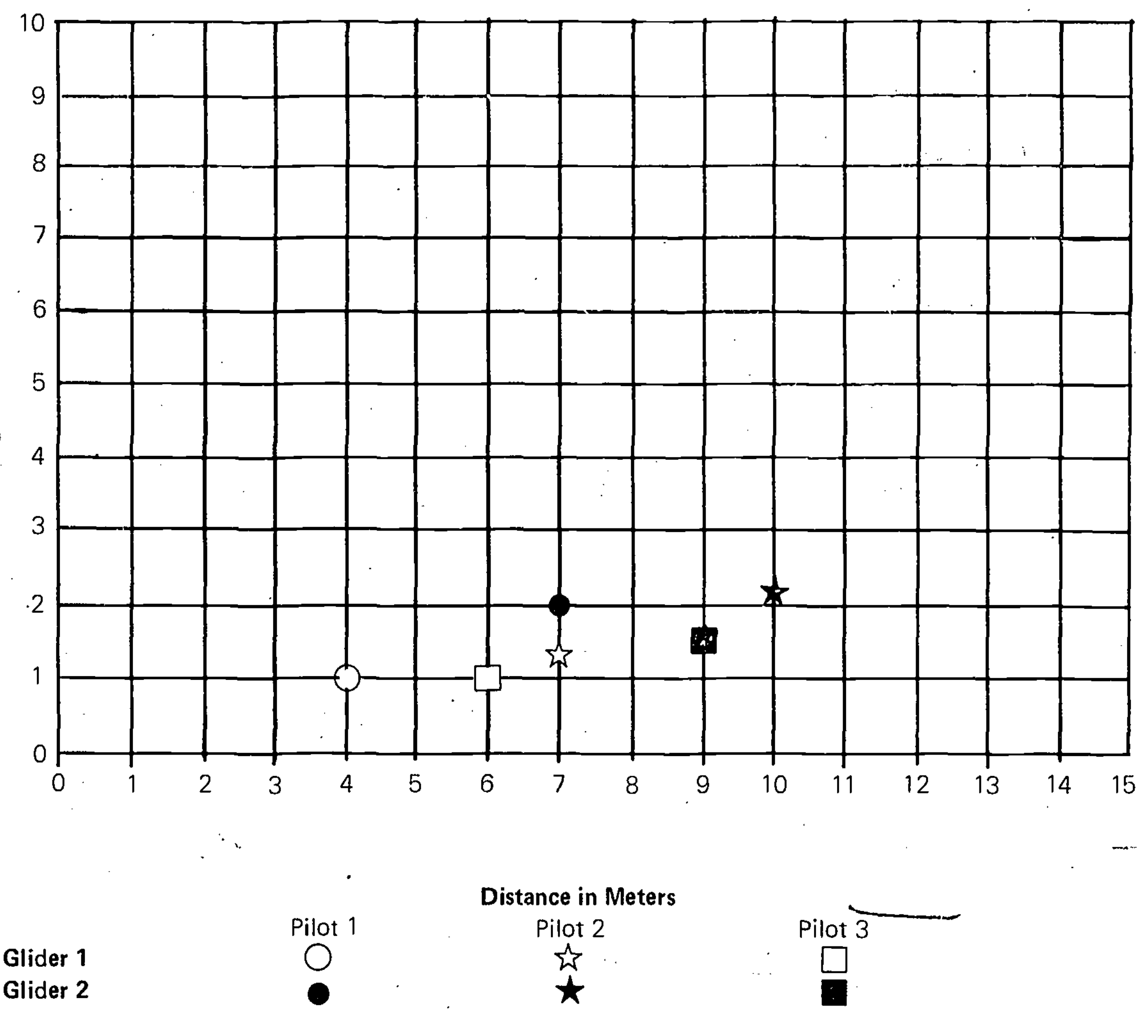
Materials Required.

- Meter stick
- Stopwatch or watch with second hand
- Graph paper
- Metric balance
- Centimeter rule
- Paint brush (optional)
- Gliders

Practice using the units of the metric system by constructing your own gliders (paper airplanes) and comparing their speed and distance.

Team up with two partners of your choice. As two of you fold the gliders, one can set up a graph for recording the distances the gliders fly and the time the gliders take in flying these distances. (See sample graph below.) All three partners should measure the length and width (where indicated) of the completed gliders with a metric ruler. Weigh each of the gliders using metric units to the nearest 1/10 of a gram. Record measurements and weights for later use.

Take turns flying each of the gliders several times, measuring the distance of each flight and clocking the time for each flight with a stopwatch or watch with a second hand. On the graph the non-pilot should record the distance to the farthest point each pilot flew Glider 1 and Glider 2.



Questions to Consider

Using the Weights and Measurements of the Gliders

1. Which glider is heavier? Give each of the weights in milligrams, centigrams, grams, and kilograms.
2. Give each of the linear measurements in millimeters, in centimeters, in decimeters, in meters.
3. Which glider is longer? wider?
4. What is the measurement in square centimeters (cm^2) of the surface area of each of the gliders? (You may have to estimate some quantities.)

Using the Graph

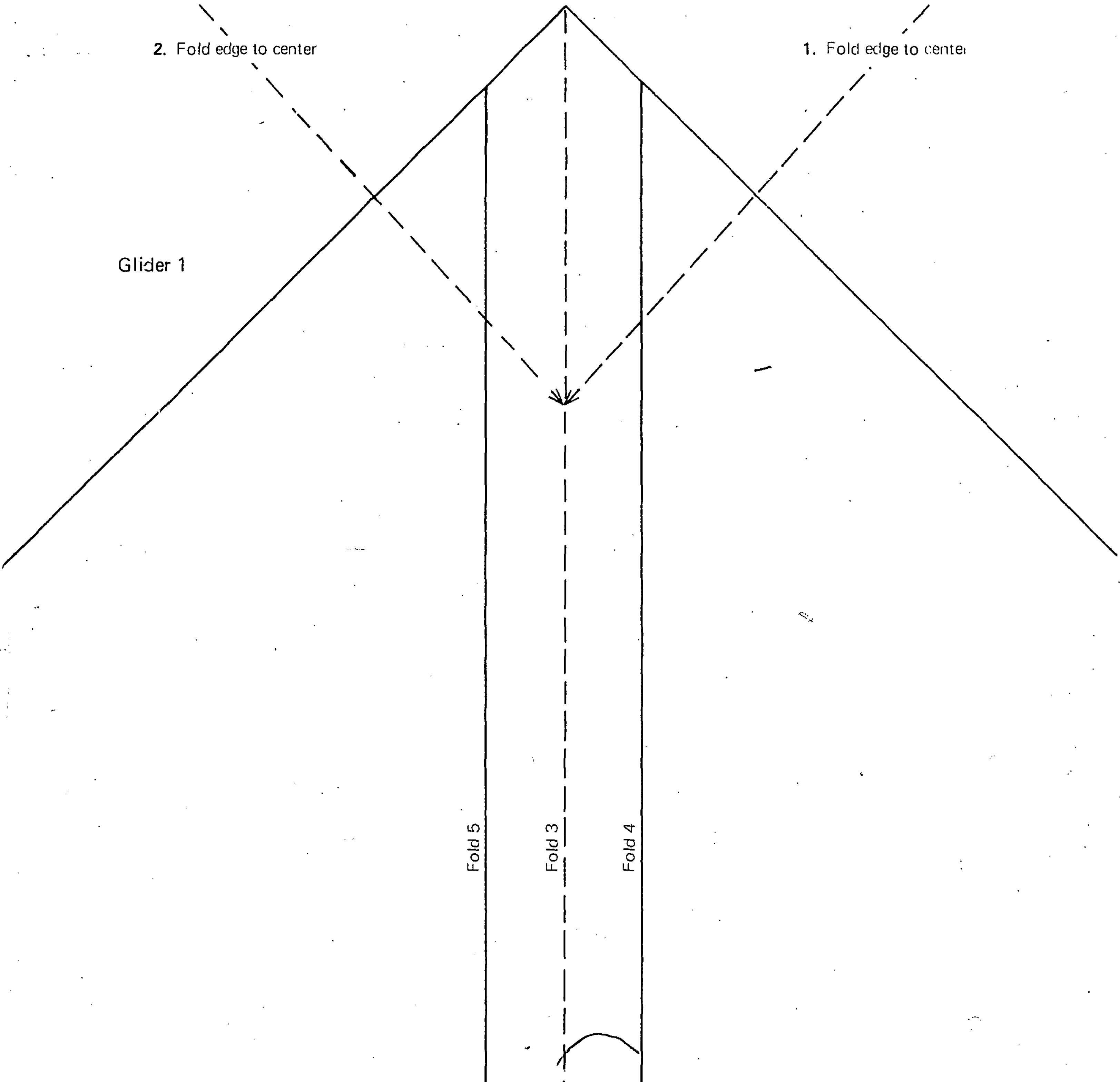
1. What does the graph show?
2. Find the time it takes for each glider fo fly the same distance.
3. Did each glider take the same number of seconds to fly the same distance?
4. Did the heavy glider fly faster? Did the heavy glider fly a greater distance?
5. Did different pilots fly the gliders the same distance in a shorter amount of time?
6. Did the gliders improve their speed over longer distances?
7. Did the glider with the greater surface area fly faster or slower? a greater distance or a lesser one?

Using Your Head

1. Would Glider 1 or Glider 2 fly the same distance in freezing weather (0° Celsius) as it would at 50° Celsius? the same speed? Why do you think so?
2. From your piloting experience, which glider would you choose as the best design for distance? for speed? Why?
3. How will the gliders fly if they are wet? Do the planes fly farther? Do they fly at all? Why?
4. Which glider would fly the greater distance if there were a heavy wind (10 meters per second)?
5. Do you have enough information to design a glider which will fly farther than either of these gliders? What items would you need to consider (measurements, weight, etc.)?

For Further Exploration

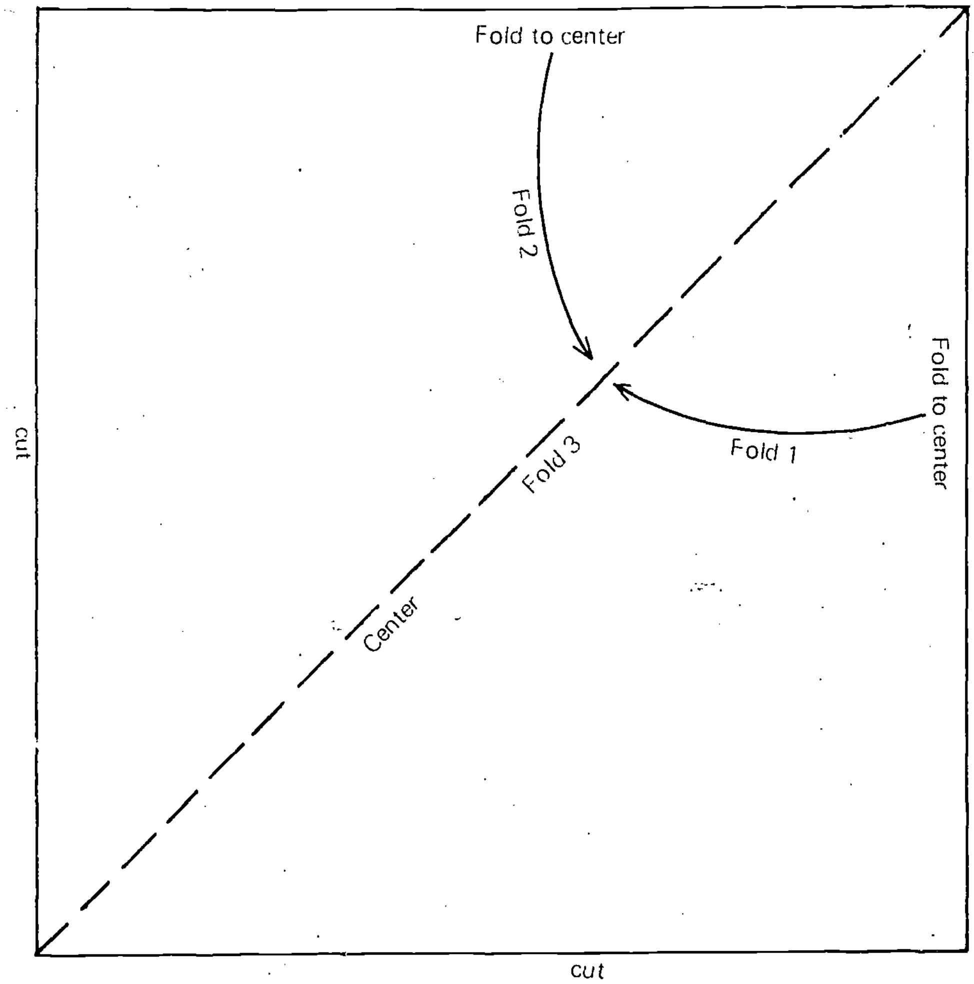
1. Wet each glider in water (use a paint brush to spread the water) and try flying them, recording flight distances and times on a graph and comparing them to your original results.
2. Use a bellows, an electric fan, the wind out-of-doors, etc., to see which glider flies a greater distance and/or at a greater speed (with the wind and against the wind).
3. Construct smaller models of Glider 1 and 2 or other paper planes and compare their distances and flight times to results for Gliders 1 and 2.



Directions to Construct Glider 1

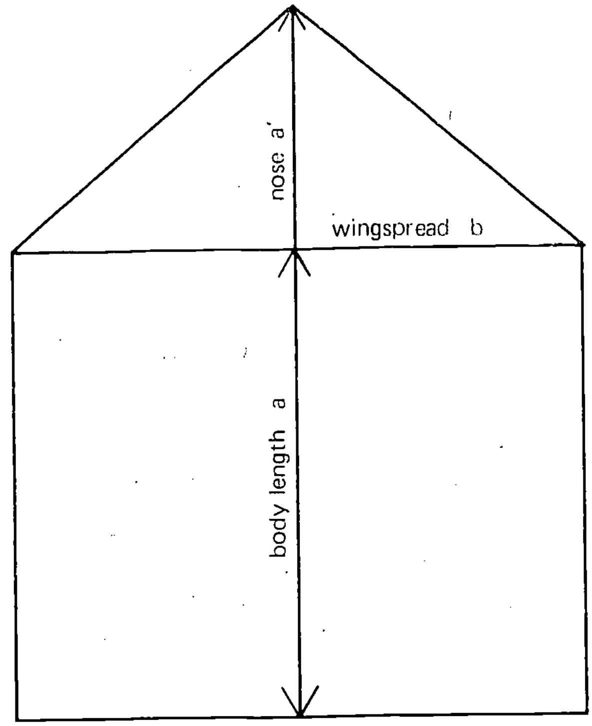
Fold right and left corners on diagonal lines to broken line. Bring outside long edges together and crease on center dotted line. Fold the two edges back on the solid lines. Folds 3, 4, and 5 should be sharp creases.

Glider 2



Cut a square of paper like the above or larger. Different weights of paper may be used. Fold the right edge and then the left edge to meet at the center line. Crease on the center fold, turning the folded edges inside. Now bring the short side to the center fold and crease. This will form a long narrow glider.

Completed Glider 1



Dimensions

Nose length ________ cm

Body length ________ cm

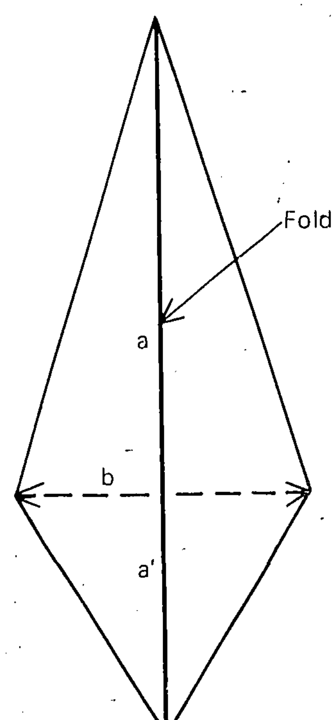
Total length ________ cm

Wingspread ________ cm

Surface

$a \times b + \frac{a' \times b}{2}$ ________ cm^2

Completed Glider 2



Dimensions

Total length

$a + a'$ ________ cm

Total width b ________ cm

Surface

$\frac{a \times b}{2} + \frac{a' \times b}{2}$ ________ cm^2

Metric in a Thermometer

Calibrating and Using a Celsius Thermometer
(calibrate – to mark the units; in this case, the degrees)

Materials Required:

- uncalibrated alcohol thermometer
- stopwatch or watch with a second hand
- 3 graduated 400 cubic centimeter (cm^3 or 400 ml beakers)
- crushed ice
- ice water
- adhesive tape
- bunsen burner
- centimeter rule
- distilled water

How a thermometer works. A thermometer contains something (usually a liquid) that expands when it is warm and contracts when it is cold. The liquid in the thermometer tube is colored so that we can see it. The position of the liquid indicates temperature. Look at the classroom thermometer. It will tell you the temperature in the room.

Choose a partner to help you make your own Celsius thermometer. Use the uncalibrated thermometer (one which has no degrees marked) supplied with this exercise or by your teacher. Practice looking for the top of the column of liquid in the thermometer. Now you are ready to mark the degrees for the temperature scale.

Place the bulb of the thermometer in a container of *melting crushed ice* while your partner uses a stopwatch or the second hand of a watch to let you know when two minutes are up. Leave the thermometer in the container and find the top of the column of liquid. When both partners have seen the top of the column, quickly mark a line at that point with a thin strip of adhesive tape. What point have you found on the thermometer? Warm the thermometer in your hand before each measurement.

Repeat once or twice until you are certain that your measurement is correct. Have you guessed that this is the freezing point of water? Then label it 0° Celsius.

Place the thermometer in a container of *ice water* (with no ice) and measure the temperature after three minutes, after two minutes, and after one minute. Record the results in the appropriate chart.

Fill a graduated fireproof beaker almost full of water. Heat until the water is boiling (water is bubbling and steam is escaping.) Hold (carefully) or suspend the thermometer so that the bulb of the thermometer is in the water. Keep it there for three minutes. Find the level of the liquid in the thermometer. Mark this point with the pencil or tape. Call this temperature 100° Celsius or the boiling point of water.

Measure the temperature of the boiling water for two minutes and again for several times until you are sure the mark is accurate.

Dry the thermometer and measure the distance between the 0° Celsius mark and the 100° Celsius mark with your centimeter rule. Divide that distance into two equal parts; make the center point of the thermometer read 50° Celsius. To make the scale more complete divide the total measurement between 0° and 100° Celsius into ten equal parts, measuring and marking these distances on the thermometer. Use 50° as a checking point for the fifth mark. Each of these divisions should represent 10 Celsius degrees.

Measure out 200 cm^3 of water into a beaker and freeze. Measure 200 cubic centimeters (or 200 ml) of water and heat to boiling in a fireproof beaker that will hold at least 400 cm^3. Remove from heat and transfer to a clean beaker. Crush the 200 cm^3 of melting ice and add to boiling water in the clean beaker. Place the thermometer in this beaker and measure the temperature of the water in the beaker after 1 minute. Record this temperature. Note the time. Wait 2 minutes and again measure the temperature of the mixture of melting ice and boiling water. Record the temperatures, wait 2 minutes and measure again.

Measure the temperature at various places in the room. Hold the thermometer in your fist for two minutes. In the chart, record these and other measurements that may occur to you.

Melting Ice	
Temperature[1]	Time
0° Celsius	3 min
	2 min
	1 min

Boiling Water	
Temperature[1]	Time
100° Celsius	3 min
	2 min
	1 min

Mixture of Melting Ice and Boiling Water	
Temperature[1]	Time
	3 minutes
	2 minutes
	1 minute

Temperature[1]	Time	Substance
	3 minutes	Boiling Water
	3 minutes	Melting Ice and Boiling Water
	3 minutes	Melting Ice

[1] Specify temperature as above or below calibrated temperatures (0°C or 100°C)

Other Locations	Temperatures
on window sill	
on floor	
at heating unit	
in balled fist	

Questions to Consider

Using the Data

1. Why must the thermometer remain in the melting ice or boiling water for a certain time before the temperature is read?
2. Is this time factor equally important for every temperature measurement? Why or why not?
3. If temperatures were measured for (1) melting crushed ice mixed with boiling water, (2) boiling water, and (3) melting crushed ice (in that order) would the time factor be equally important? more important? less important? Why?
4. Why must you measure the temperature of ***melting ice*** rather than ***ice water*** to find the freezing point of water on the Celsius temperature scale?
5. Why do you need to make several measurements before making the final marking on your thermometer?
6. Is the thermometer sensitive? (That is, does the position of the liquid change quickly?)
7. Why must the water come to a rolling boil rather than a gentle boil before you measure the boiling point of water?
8. Water boils below 100°C at high altitudes. Why?

Using Your Head

1. Will every thermometer containing a liquid require the same attention to time as your thermometer? Why or why not?
2. Is your thermometer likely to be as accurate as one calibrated at a factory? Why or why not?
3. Why do calibrated thermometers (those which have a temperature scale) have so many fine divisions?
4. Why should the thermometer not be handled when you are measuring the temperature of the ice and water?

For Further Exploration

1. What are some substances (liquid or non-liquid) other than alcohol which are used in thermometers?
2. Can you measure the temperature of everything with the liquid type of thermometer? Why or why not?
3. When would you use thermometers not containing a liquid?
4. To understand better how a thermometer operates try the following activity:

Measure 200 cubic centimeters of melting crushed ice into a graduated beaker (as exactly as possible) while your partner also measures the same amount of water. One beaker should be heated until the water is boiling.

Compare the two samples of water carefully by drawing a picture of each beaker and listing all of the differences that you notice.

Let the two beakers stand at room temperature until they are both about the same temperature. (Check to see whether they are the same by using the thermometer.) Compare the two with each other and with your previous diagrams.

Answer Key to Metric Exercises

Measuring Length and Distance

1. 1,000; 10
   100
   10
   1,000

2. 70
   700
   7,000
   1,000
   1
   .5
   100
   5,000
   2

3. 26
   260
   2,600

4. 1,000 cm
   .01 km

Practicing the Units of Length and Distance

1. km
2. m
3. cm
4. m
5. m

Recognizing Everyday Metric

1. liter
2. kilometer
3. kilometers per hour
4. degrees Celsius
5. meters
6. kilograms
7. grams
8. liter

Changing from One Unit to Another
Estimating and Measuring

1. 860; 8,600
   750; 7,500
   302; 3,020
   81; 810
   75; 750
   2; 20
   50; 500
   42; 420
   20; 200

2. 6.25 cm

3. 1 m 85 cm; 1.85 m
   3 m 76 cm; 3.76 m
   5 m 92 cm; 5.92 m
   0 m 50 cm; .50 m
   11 m 5 cm; 11.05 m

Traveling in Metric

1. 5
   45.5
   27
   50,860.5 km
   6.46 km/l
2. aunt's; it is too far; 28 km

Jumping in Metric

1. 109 cm – difference
   # 2 simplest
   1 m 50 cm – average

Learning about Weight

1. 1,000
   1,000
2. .5
   .25
   2,000
   5,000
   3
   .5
   1
   .01
   .450
   2

Changing from One Unit to Another–
Practicing Metric Weights

1. 5 kg 860 g; 5.860
   8 kg; 8
   3 kg 500 g; 3.500
   7 kg 250 g; 7.250
   1 kg 5 g; 1.005
3. 500
   150
   600
   1,300
   250

   750
   1,000
   500
   3,000
4. 3 kg (3,000 g)
5. 1,000 g or 1 kg
   100 g or .1 kg
   300 g or .3 kg

7. Differences
   8.8
   4.9
   4.1
   6.6
   1.1
   5.1 kg average change
   4.66 kg average gain
8. 1,000 g (.065 cents per gram)

Measuring Volume in Metric

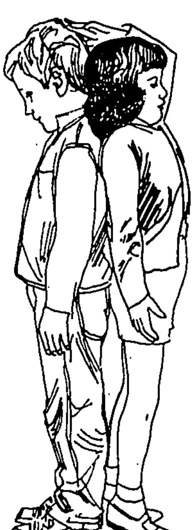
1. 1,000 (10 cm X 10 cm X 10 cm)
   1,000 (10 dm X 10 dm X 10 dm)
   1
   10
2. 1
   6
   6
   .5
   80
   1
   4
   1,000

Practicing Volume in Metric

1. 4
   4
   5
   10

Putting It All Together

1. 10 g
   70 g
   6 kg
   40 kg
   100 kg
   .5 kg
2. 37.5°
   -10°
   40°
   20°
   0°
   100°
3. 1 liter
   15 ml
   .25 l
   50 l



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Washington, D.C. 20036

FIRST LESSONS IN THE METRIC SYSTEM OF MEASUREMENTS

Metric is coming. Even now, metric measurements are becoming so prevalent that all of us must be familiar with these measurements. Very probably within ten years or so, metric units of measurements will be the predominant units -- if not the exclusive legal units -- used in the United States. This is already the situation in all other major countries of the world. While we wonder why it took the British so long to convert their currency to a decimal system, other countries wonder why the United States clings to its confusing and cluttered system of measurements, when a decimal system is so much simpler. We recognize this simplicity from our own dollar with its decimal base. And what is metric? **A system of scientifically standardized units of measurement in which multiples and subdivisions of the units are related by 10 or a power of 10.**

Metric is coming. Everyone needs to become familiar with the metric system, and students should be learning metric along with their early concepts of measurement and their first skills in measuring.

A Measurement System

Measurements are quantified descriptions. They serve to describe the size or volume, the weight or mass of an object. They describe the distance between two points, the amount of time that elapses between events, the temperature and brightness that we experience in the air around us. They can provide these descriptions in a very rough way or with extreme precision.

We express measurements -- these quantified descriptions -- in units to which we assign some arbitrary name, such as hours, for example. An individual can measure a quantity in any terms he chooses; he may make up his own units and names for them. He can measure the length of the desk or the width of the room in **strings**, even to the hundredths or thousandths of a string, and arrive at an excellent quantified description of the length of the desk and the width of the room. But he cannot communicate this description to anyone else unless that person knows the exact length represented by one **string**.

There must be a standard for the **string**, or for any other unit of measurement. Any useful system of measurements must be built on standards that mean exactly the same thing to everyone who uses the units of measurement. When we speak of 15 minutes, we know exactly the duration of time described. When we buy a pound of butter in New York or in San Francisco, we will receive exactly the same amount, because the pound is a standard unit known and agreed to throughout the United States. Ideally the units which we use as standards are related to some fixed natural quantity so that they can be reproduced anywhere in the world even if the original prototype is destroyed.

For convenience, we also establish units to measure widely varying quantities -- the width of the room and the distance between two cities, for example. We would not measure a room in inches or miles, or a postcard in feet. We certainly could, but we would obtain very clumsy fractions or extremely large numbers. Therefore, we often have several units for each dimension -- for time, length, volume, etc. In practical use we convert from one of these units to another. Therefore, for convenience we need a constant relationship between the units for the same dimension. In the everyday units of the metric system (with the exception of time) these relationships are based on ten.

Thus, measurement and the communication of and about measurements require standard units that are

- well-recognized by everyone
- reproducible
- appropriate for their use
- composed of easily converted units and subunits
- easily manipulated in arithmetic computations

The metric system is such a system of standards. Developed in France in the late 1700s, it has been constantly extended and refined since that time. The official name for the modernized metric system is the International System of Units (SI). It is this

Metric Is Coming Stock Number 471-14662 75 cents.

page 4 for purchase information.

system which is increasingly being used in the United States, even before Congress acts on the recommendations to "go metric." A brief history of the metric system is given on page 5.

the SI (metric) system

The everyday units of the metric system are:

Quantity to be measured	Name of unit	Symbol
Length	meter	m
Mass	kilogram	kg
Temperature	Celsius	°C
Volume	liter or cubic meter	l m^3 (m x m x m)
Time	second	s

Note: The table on page 4 includes other units that the students do not need for everyday use.

Mass and weight are not the same thing. Mass is inherent in a body and refers to its resistance to acceleration. Weight is really a force (the pull of gravity on a body). Mass does not change with position of the body; weight changes with gravity. Thus, on the moon, a body has the same mass as it would have on earth but less weight since gravity is less on the moon. There is a great deal of confusion and controversy about the use of the term kilogram to measure weight as well as mass. Scientists measure weight (the force of gravity) in newtons. It is important to keep the distinction between mass and weight in mind and help students use the appropriate terms and concepts.

The precise value for each unit has been carefully established by scientists and agreed upon by the various nations of the world. Units, larger units, and subunits relate to each other in powers [1] of 10. This greatly simplifies computations.

For example, which problem is easier to figure out?

1. What is the area (inches^2) of one-half a square yard?
2. What is the area (cm^2) of one-half of a square meter?

Problem 1 requires this computation:

$$\frac{36'' \times 36''}{2} \quad \text{or} \quad 18'' \times 36''$$

which most people would need to work out on paper.

Problem 2 requires this computation:

$$\frac{100\text{ cm} \times 100\text{ cm}}{2} \quad \text{or} \quad 50\text{ cm} \times 100\text{ cm}$$

Many people could do this easily in their heads or with much less effort.

Prefixes attached to the name of the base unit indicate the relationship of that unit to the base unit. The same prefixes are used with multiples of different units (length, or mass, for example) to indicate relation to the base units. Kilo- always indicates 1,000 of the unit; centi- always means one one-hundredth of the unit (just as our cent always means one one-hundredth of a dollar).

[1] Power is the number of times the number is used as a factor.

teaching the metric system

Before children can understand the metric system or any other system of measurement, they must have some experience in measuring and in communicating about the measurements they obtain. They quickly grasp the value of standard units if they experiment with their own made-up units.

As soon as the measurement concepts have been introduced, begin directly with the metric system.

Avoid conversion exercises; concentrate on using the metric system itself.

learning the units

Gradually introduce the various units and the devices used to measure in these units by demonstrating the following and by setting up activities appropriate for the grade level.

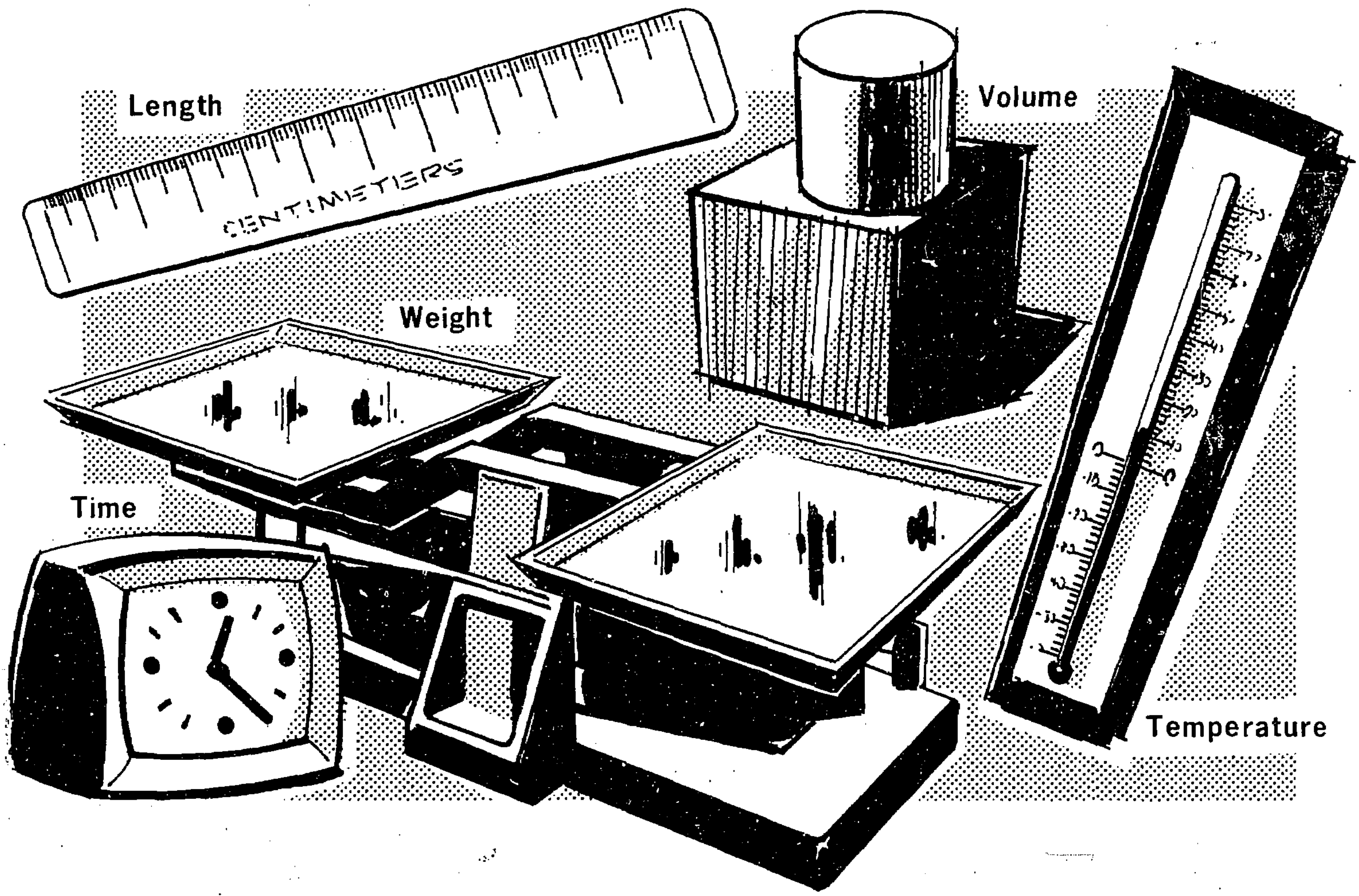
Device	Quantity	Metric Unit
Meterstick	length, area, volume	meter, centimeter decimeter
Balance	weight (or mass).	kilogram, gram
Clock	time	second
Container	volume	liter, deciliter, cubic meter cubic centimeter
Thermometer	temperature	degrees Celsius

prefixes

Names of the multiples and submultiples of the metric units are formed by means of the following prefixes:

Number of Base Units	Prefix	Symbol	
1,000,000	mega	M	
1,000	kilo	k	kilometer (km), 1,000 meters; kilogram (kg), 1,000 grams, etc.
100	hecto	h	
10	deka	da	
.1	deci	d	deciliter (dl), 1/10 liter
.01	centi	c	centimeter (cm), 1/100 meter
.001	milli	m	millimeter (mm), 1/1000 meter
.000001	micro	μ	microgram (μg)

Note, however, that the kilogram is considered the standard base unit in the SI system, because it is a more convenient sized unit.



Ask the students a few questions and encourage them to fill in the name of the unit that belongs in the answer, such as: How wide is your desk? One meter.
I am 1½____tall.
It's hot today. The thermometer reads 35____.

Then ask the students to ask each other questions which require the use of the name of the correct unit in the answer so that they will learn the names of the units that correspond to certain dimensions. Following are a few clues:

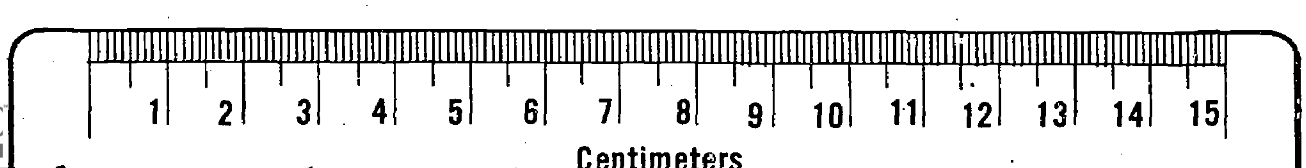
How long, how wide, how high, how far, how tall	meter (length)
How heavy	kilogram (or newton)
How massive	kilogram
How soon, how late, when	second (time)
What volume	liter or cubic meter
How hot, how cold	degrees Celsius (temperature)

practice making measurements

Provide metric rulers for the students and let them practice measuring length and area. If possible each student should have his own ruler. Use items that will demonstrate how and why to choose larger or smaller units, such as meters or centimeters. If metric rulers are not available, the border on this brochure can be copied to make paper rulers.

Using liter containers (which can be a box 10 centimeters on each side) or beakers or graduated cylinders calibrated in metric units, the students can practice measuring volume. Other exercises can be arranged for weight and temperature.

remember - use **metric** ... don't convert!



generally used equivalents in the metric system

Length

millimeter	mm	10 mm	= 1 centimeter
centimeter	cm	100 cm	= 1 meter
meter	m	1,000 m	= 1 kilometer
kilometer	km		

Mass (weight)

gram	g	1,000 g	= 1 kilogram
kilogram	kg	1,000 kg	= 1 metric ton or tonne (t)
metric ton			

Volume

milliliter	ml	1,000 ml	= 1 liter
deciliter	dl	10 dl	= 1 liter
cubic centimeter	cm^3	1,000 cm^3	= 1 cubic decimeter = 1 liter
cubic decimeter	dm^3	1,000 dm^3	= 1 cubic meter
cubic meter	m^3		

Time

second	s	60 s	= 1 minute

Metric Units and Numerical Relationships

Dimensions	Metric units						
mass (weight) grams	milligram mg .001	centigram cg .01	decigram dg .1	gram g 1	dekagram dkg 10	hectogram hg 100	kilogram kg 1000
volume liter	milliliter ml .001	centiliter cl .01	deciliter dl .1	liter l 1	dekaliter dkl 10	hectoliter hl 100	kiloliter kl 1000
length meter	millimeter mm .001	centimeter cm .01	decimeter dm .1	meter m 1	dekameter dkm 10	hectometer hm 100	kilometer km 1000

When converting from one unit to the next unit to the right,
multiply by 10

cg to dg

.01 X 10 = .1

When converting from one unit to the next unit to the left,
divide by 10

km to m

1000 ÷ 10 ÷ 10 ÷ 10 = 1

The seven base units of the SI metric system are:

SI base units

Name	Symbol	Quantity
meter	m	length
kilogram	kg	mass[1]
second	s	time
ampere	A	electric current
kelvin	K	thermodynamic temperature[2]
mole	m	amount of substance
candela	cd	luminous intensity
[1] Newton	N	weight (force of gravity)
[2] Celsius temperature may also be used	°C	

The International System of Units (SI).
National Bureau of Standards Special Publication 330.
1972 Edition. SD Catalog No. C 13.10:330/2.
…ntendent of Documents, U.S. Government Printing Office,
…gton, D.C. Price 30 cents.

metric exercises

The National Science Teachers Association has prepared a kit of metric exercises appropriate for grades one through junior high school. It contains a copy of this brochure, a pad of illustrated paper and pencil exercises, diagrams and instructions for lively activities on length, weight, volume, and temperature, as well as a metric ruler, paper squared in centimeters, an uncalibrated thermometer tube, and a 1 gram centimeter cube.

Stock No. 471-14664 Price $6.00

Order Metric Exercises ($6.00) and Metric Is Coming (75 cents) from
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brief history of the metric system

The need for a single worldwide coordinated measurement system was recognized over 300 years ago. Gabriel Mouton, Vicar of St. Paul in Lyons, proposed in 1670 a comprehensive decimal measurement system based on the length of one minute of arc of a great circle of the earth. In 1671 Jean Picard, a French astronomer, proposed the length of a pendulum beating seconds as the unit of length. Other proposals were made, but over a century elapsed before any action was taken.

In 1790, in the midst of the French Revolution, the National Assembly of France requested the French Academy of Sciences to "deduce an invariable standard for all the measures and all the weights." The Commission appointed by the Academy created a system that was, at once, simple and scientific. The unit of length was to be a portion of the earth's circumference. Measures for capacity (volume) and mass (weight) were to be derived from the unit of length, thus relating the basic units of the system to each other and to nature. Furthermore, the larger and smaller versions of each unit were to be created by multiplying or dividing the basic units by 10 and its multiples. This feature provided a great convenience to users of the system, by eliminating the need for such calculations as dividing by 16 (to convert ounces to pounds) or by 12 (to convert inches to feet). Similar calculations in the metric system could be performed simply by shifting the decimal point. Thus the metric system is a "base-10" or "decimal" system.

The Commission assigned the name metre (which we now spell meter) to the unit of length. This name was derived from the Greek word metron, meaning "a measure." The physical standard representing the meter was to be constructed so that it would equal one ten-millionth of the distance from the north pole to the equator along the meridian of the earth running near Dunkirk in France and Barcelona in Spain.

The metric unit of mass, called the "gram," was defined as the mass of one cubic centimeter (a cube that is 1/100 of a meter on each side) of water at its temperature of maximum density. The cubic decimeter (a cube 1/10 of a meter on each side) was chosen as the unit of fluid capacity. This measure was given the name "liter."

Although the metric system was not accepted with enthusiasm at first, adoption by other nations occurred steadily after France made its use compulsory in 1840. The standardized character and decimal features of the metric system made it well suited to scientific and engineering work. Consequently, it is not surprising that the rapid spread of the system coincided with an age of rapid technological development. In the United States, by Act of Congress in 1866, it was made "lawful throughout the United States of America to employ the weights and measures of the metric system in all contracts, dealings or court proceedings."

By the late 1860's, even better metric standards were needed to keep pace with scientific advances. In 1875, an international treaty, the "Treaty of the Meter," set up well-defined metric standards for length and mass, and established permanent machinery to recommend and adopt further refinements in the metric system. This treaty, known as the Metric Convention, was signed by 17 countries, including the United States.

As a result of the Treaty, metric standards were constructed and distributed to each nation that ratified the Convention. Since 1893, the internationally agreed-to metric standards have served as the fundamental weights and measures standards of the United States.

Today, with the exception of the United States and a few small countries, the entire world is using predominantly the metric system or is committed to such use. In 1971 the Secretary of Commerce, in transmitting to Congress the results of a 3-year study authorized by the Metric Study Act of 1968, recommended that the U. S. change to predominant use of the metric system through a coordinated national program. The Congress is now considering this recommendation.

The International Bureau of Weights and Measures located at Sèvres, France, serves as a permanent secretariat for the Metric Convention, coordinating the exchange of information about the use and refinement of the metric system.

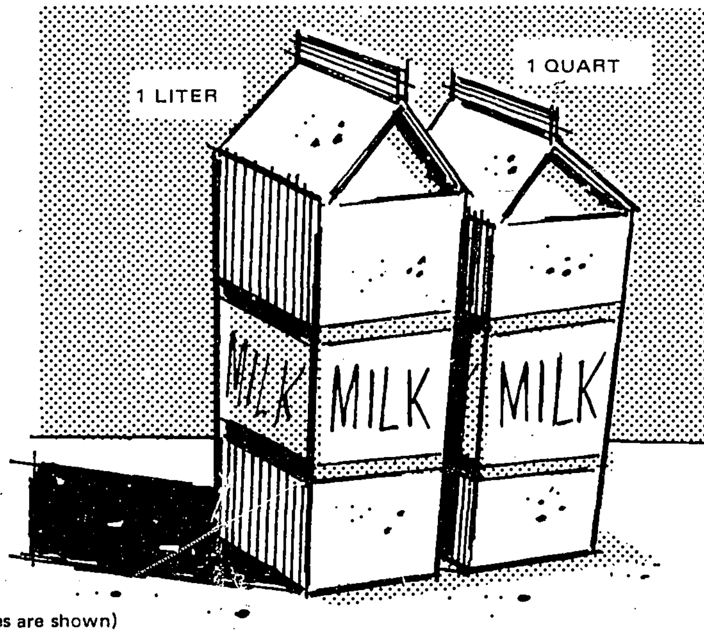
In 1960, the General Conference adopted an extensive revision and simplification of the system. The name Le Système International d'Unités (International System of Units), with the International abbreviation SI, was adopted for this modernized metric system. Further improvements in and additions to SI were made by the General Conference in 1964, 1968 and 1971.

From "Brief History of Measurement Systems with a Chart of the Modernized Metric System." National Bureau of Standards, Special Publication 304 A.

Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. October 1972.

useful comparisons

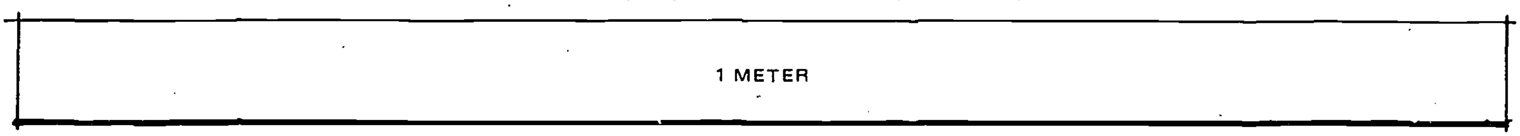
Teachers and older children who are already familiar with our customary units of measure will undoubtedly want to make some conversions from this system to metric units and will find it useful to keep some general comparisons in mind. Following are the comparisons suggested by the National Bureau of Standards and approximate conversions between the systems.

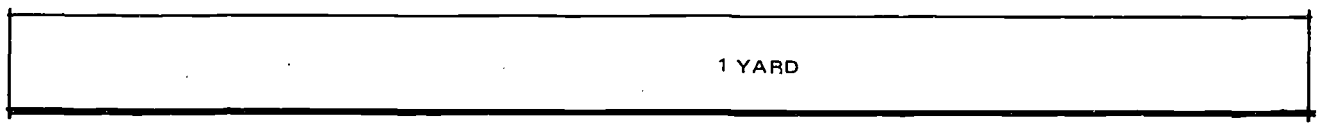


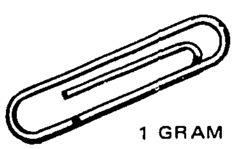
BASIC UNITS

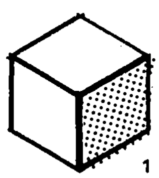
METER: a little longer than a yard (about 1.1 yards)
LITER: a little larger than a quart (about 1.06 quarts)
GRAM: about the weight of an ordinary paper clip

(comparative sizes are shown)

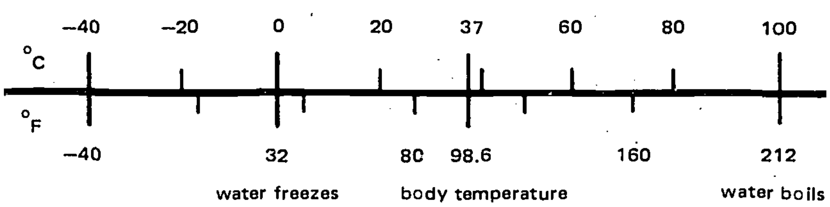






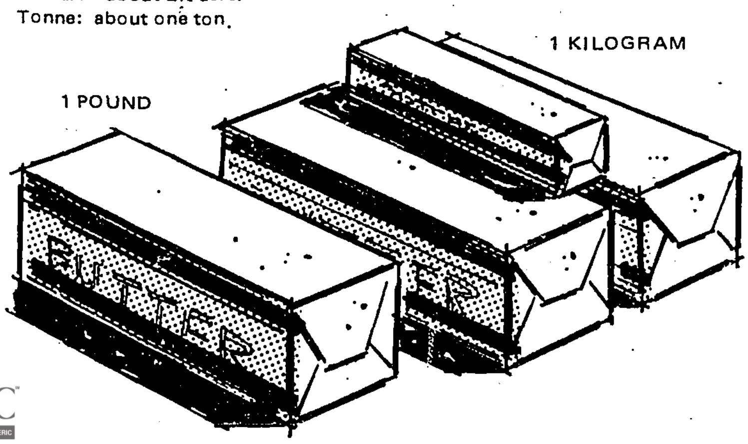


We recognize that there may be occasions when it will be convenient to convert from our customary units to metric units and therefore have included the following conversion tables for that purpose.



OTHER USEFUL UNITS

Hectare: about 2½ acres
Tonne: about one ton.



METRIC CONVERSION FACTORS

Approximate Conversions
to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 cm (exactly).

Source: National Bureau of Standards Letter Circular 1051, July 1973.